Bennelongia Environmental Consultants

Mt Morgans Gold Project: Short-Range Endemic Fauna Desktop Assessment

Prepared for:

Dacian Gold Limited

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Final Report

Short-Range Endemics I Subterranean Fauna

Waterbirds I Wetlands

Mt Morgans Project: Short-Range Endemic Fauna Desktop Assessment

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EXECUTIVE SUMMARY

Introduction. Dacian Gold Limited (Dacian) is planning to develop the Mt Morgans Gold Project (the Project) in the northern goldfields of Western Australia, located approximately 35 km south west of Laverton. The Project is a brownfields site that encompasses three historic operational areas, comprising:

- Westralia: Containing the Westralia and Transvaal pits, other satellite pits and historical processing areas;
- Jupiter: Containing the Jupiter pit and heap leach area, located approximately 15 km to the east of Westralia; and
- The Mt Morgans and Jupiter Borefields (hereafter referred to as the production borefield).

Dacian proposes to develop three open pits at Jupiter and three underground mines at the Westralia. Associated infrastructure development will include a processing plant, tailings storage facility, Run of Mine Pads (ROMs), waste rock dumps, power plant, workshops, administration offices, camp, pipelines and roads.

A desktop assessment was completed to provide information about the occurrence of short-range endemic (SRE) and listed invertebrate species across the Project area, and to assess the potential impact on this fauna from the proposed mining operation.

Methods. A desktop review was undertaken to collate existing data on SREs occurring in the vicinity of the Project, as well as invertebrate species listed as Specially Protected or Threatened fauna. Information contained in published literature, publically available environmental reports and online databases were reviewed with regards to SRE species and their habitats. The databases of the Western Australian Museum (WAM) were searched to identify potential and confirmed SRE species in the vicinity of the Project, and the taxonomic groups that may occur locally. SRE status of species from the Project area and its vicinity was assessed according to the WAM SRE categories. All available landforms and macrohabitats in the study area were mapped and classified with regards to their suitability for SRE fauna.

Results. The desktop review showed that that there are three habitat types in the survey area that have a moderate or high prospect for SRE fauna: BIF Ridges, Minor Drainage Lines and Woodlands. BIF ridges are by far the least common habitat type in the survey area and are too small to support diverse SRE communities. The Minor Drainage Lines and Woodlands are more common but not restricted at a local, sub-regional or regional scale and extend far beyond the project boundaries. The SRE community in the vicinity of the Project is poorly known but appears depauperate when compared to other areas in the Goldfields. Three SRE Groups that potentially occur in the Project vicinity seem to be moderately diverse (mygalomorph spiders, scorpions and centipedes) but no harvestmen, pseudoscorpions, millipedes, slaters or terrestrial snails have been collected in the Project area or its vicinity. All named species in the SRE Groups that are likely to occur in the Project area are widespread and have known ranges that extend regionally. Some potential SRE species have been recorded but they have deficient data and their ranges cannot be assessed. One listed species, the fairy shrimp *Branchinella simplex* may occur although there are currently no records at the Project. This species is known from fresh and saline waters on clay pans and these habitats occur in the Project area. Further suitable habitat extends beyond the mapped areas and the species tolerates a wide range of salinities with a linear range of approximately 550 km. If present in the Project area, the impacts to *B. simplex* are expected to be minimal. Overall, the proposed impact areas in relation to the available habitats are very small and there are no known SRE invertebrate species from the Goldfields that have ranges smaller than the areas to be disturbed.

Conclusions. The available data suggest that Project development will not have a significant impact on SRE communities or listed species. This conclusion is reached because:

1. The most suitable habitats for SRE species at the Project area are wide-ranging, interconnected and extend far beyond the tenement boundaries;
2. The SRE Group fauna of the Project appears to be depauperate at all taxonomic levels and comprises predominantly widespread species;
3. The proposed impact areas are small and the primary impact will be on the Plains (with the western TSF option) or the Salt Pans and Tributaries (with the eastern TSF option); and
4. The habitat in which the listed species *Branchinella simplex* may occur (Salt Pans and Tributaries) will have minimal impact and this habitat occurs widely beyond the project area.

A field survey that could validate the findings of this desktop review and characterise the SRE community present is unnecessary for the reasons given above and the level of threat to such species from Project development is considered negligible. It is suggested that SRE invertebrates are not a relevant environmental assessment factor at the Mt Morgans Project.

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1. INTRODUCTION

Dacian Gold Limited (Dacian) is planning to develop the Mt Morgans Project in the Northern Goldfields of Western Australia, located approximately 35 km south west of Laverton (Figure 1). A desktop assessment was completed to provide information about the occurrence of short-range endemic (SRE) and listed invertebrate species across the Project area, and to assess the potential impact on this fauna from the proposed mining operation.

SRE invertebrates are species with distributions of less than 10,000 km^2 and their occurrence within their distributions is usually patchy because they are confined to discontinuous habitats. The small ranges of SRE invertebrates, combined with poor dispersal capacities, slow growth and low fecundity, make them particularly vulnerable to habitat loss or disturbance (Harvey 2002; Ponder and Colgan 2002). The Environmental Protection Authority's (EPA) Guidance Statement 20 (Environmental Protection Authority 2009) requires that impacts on SRE invertebrates are considered during environmental impact assessments. In practice, assessment of risk to SRE invertebrates in arid Western Australia is focused on eight taxonomic groups with a known high proportion of SRE species (the *SRE Groups*): harvestmen (Opiliones), pseudoscorpions (Pseudoscorpiones), scorpions (Scorpiones), spiders (Araneae), centipedes (Chilopoda), millipedes (Diplopoda), slaters (Isopoda), and terrestrial snails (Gastropoda).

Listed invertebrate species are those listed under the Western Australian *Wildlife Conservation Act 1950* or the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). They may belong to any invertebrate group and are listed because they potentially face severe population reduction, have lost much of their habitat, or are collected intensively.

This report assesses whether any short-range endemic (SRE) invertebrate fauna, or habitats promoting such fauna, are likely to occur at the Project. It also assesses if any listed invertebrate species or those protected otherwise under commonwealth or state legislation are likely to occur at the Project. The overall aims of the desktop assessment are to:

- Collate existing information on SREs and listed invertebrates that may occur in the vicinity or are known from within the Project area;
- Characterise habitats and classify landforms according to their suitability for listed or SRE invertebrate species;
- Compile existing data on SRE species distributions and abundance with the overarching aim of characterising the community that is potentially present; and
- Determine if the Project is likely to have significant conservation impacts on any SRE or listed aquatic invertebrate species.

For this purpose, records of species belonging to the SRE Groups or listed species were compiled for a 100 by 100 km search area surrounding the Project and their ranges estimated. Habitat mapping was also undertaken and the Project was split into distinct habitat types that were evaluated with regards to their suitability for SRE fauna. All listed invertebrate species from the Yilgarn are discussed, to evaluate their likelihood of occurrence in the Project area and potential threats to them arising from Project development.

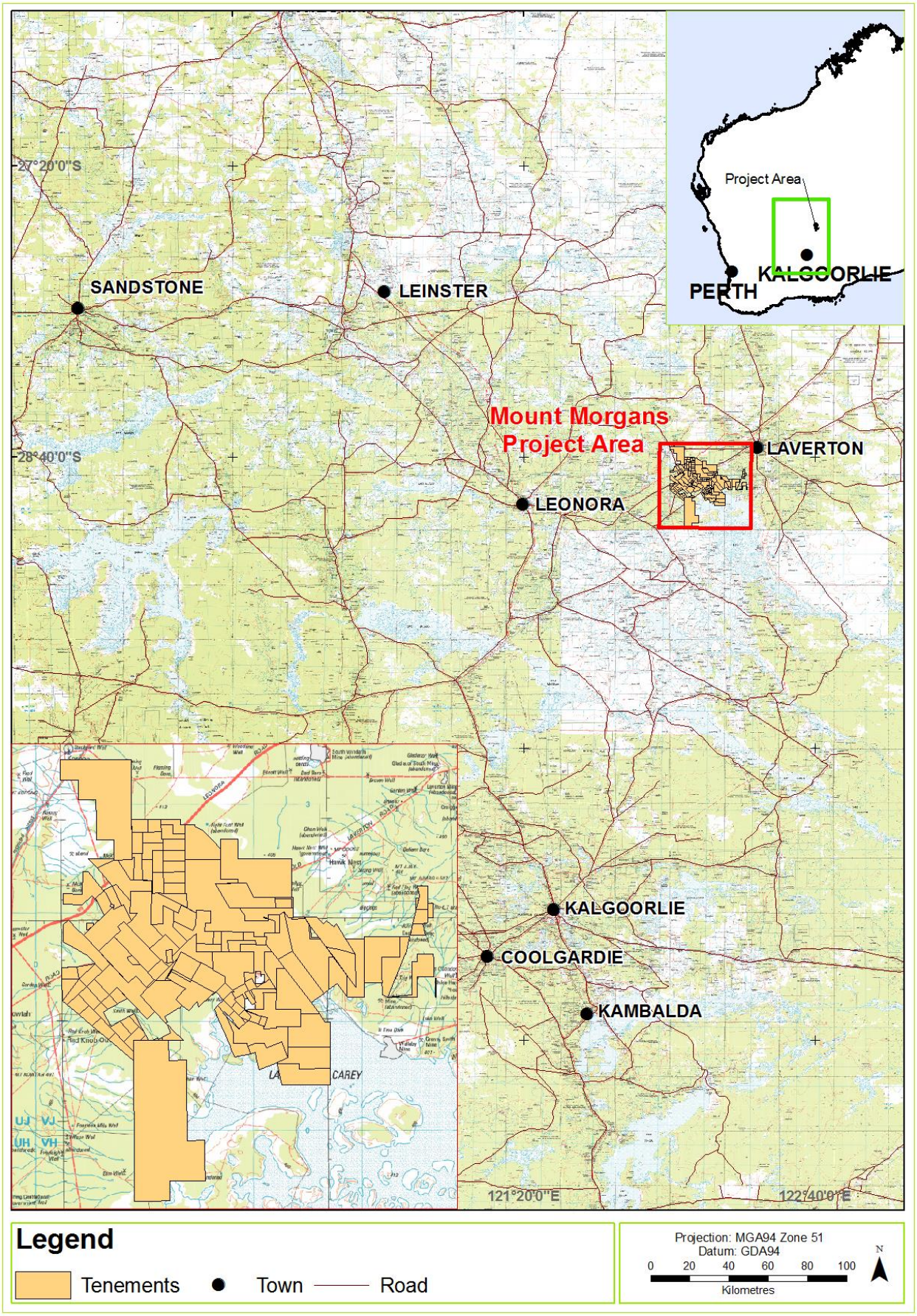

Figure 1. Location of the Mt Morgans Project area.

2. BACKGROUND

2.1. Project Details

The Project is a brownfields site that encompasses three historic operational areas, comprising:

- Westralia: Containing the Westralia and Transvaal pits, other satellite pits and historical processing areas;
- Jupiter: Containing the Jupiter pit and heap leach area, located approximately 15 km to the east of Westralia; and
- The Mt Morgans and Jupiter Borefields (hereafter referred to as the production borefield).

Dacian is proposing to commence construction and mining activities at the Project in 2017 (Blueprint 2015). Three mineral resources have been identified for development:

1. Jupiter– comprising three pit developments (Heffernans, Doublejay and Ganymede) along a 1.8 km north-south trending strike.
2. Westralia– comprising development of Westralia underground (UG), Morgans UG and Morgans North pit cutback. It is proposed to access Westralia UG via the existing Westralia pit and Morgan UG via the deepened Morgans North pit.
3. Transvaal Project - expansion of the historic Transvaal UG, with access via the historic Transvaal pit.

Approximately 16 million tonnes of ore and 73.8 million tonnes of waste will be mined over a six year period. Ore will be transported to a newly constructed carbon-in-leach processing plant, located west of the proposed Jupiter pits. The anticipated throughput of the plant is 2.5 million tonnes per annum. Tailings produced from processing will be discharged to a tailings storage facility (TSF), located within the Jupiter project area.

An overview of the Project areas and the existing and proposed conceptual layouts for Westralia and Jupiter are presented in Figure 2.

2.2. Regional Context

The Project is located in the East Murchison subregion (Cowan 2001; DSEWPC 2012) of Western Australia, approximately 35 km south west of Laverton. The East Murchison is characterised by low hills and mesas separated by flat colluvium and alluvial plains. The regional geology within the Project area is characterised by belts of greenstone separated by granites, with areas of sedimentary and volcanic rocks associated with the greenstone. The granites are generally expressed as low rounded tors surrounded by plains while the greenstones may be either low and rounded hills or steeper less weathered hills with narrow drainages (Blueprint 2015).

The Salinaland Plateau of the Yilgarn Plateau Province is characterised by "sandplains and laterite breakaways; granitic and alluvial plains; ridges of metamorphic rocks and granite hills and rises; calcretes, large salt lakes and dunes along valleys" (Pringle *et al.* 1994). The Project comprises elevated BIF ridges (20-30 m) with associated stony footslopes; sandy plains and intermittent drainage lines (Outback Ecology 2009a; Outback Ecology 2009b; RPS 2011). Generally within the region the vegetation is dominated by Mulga Woodlands that tend to form ephemerals, hummock grasslands, saltbush shrublands and *Halosarcia* shrublands (Cowan 2001). Vegetation at the site has been described to encompass: mixed *Acacia* tall shrublands in minor drainage lines; low woodland of mixed *Acacia* in minor drainage lines; Mulga groves and woodlands, Mulga/*Eucalyptus* woodlands;

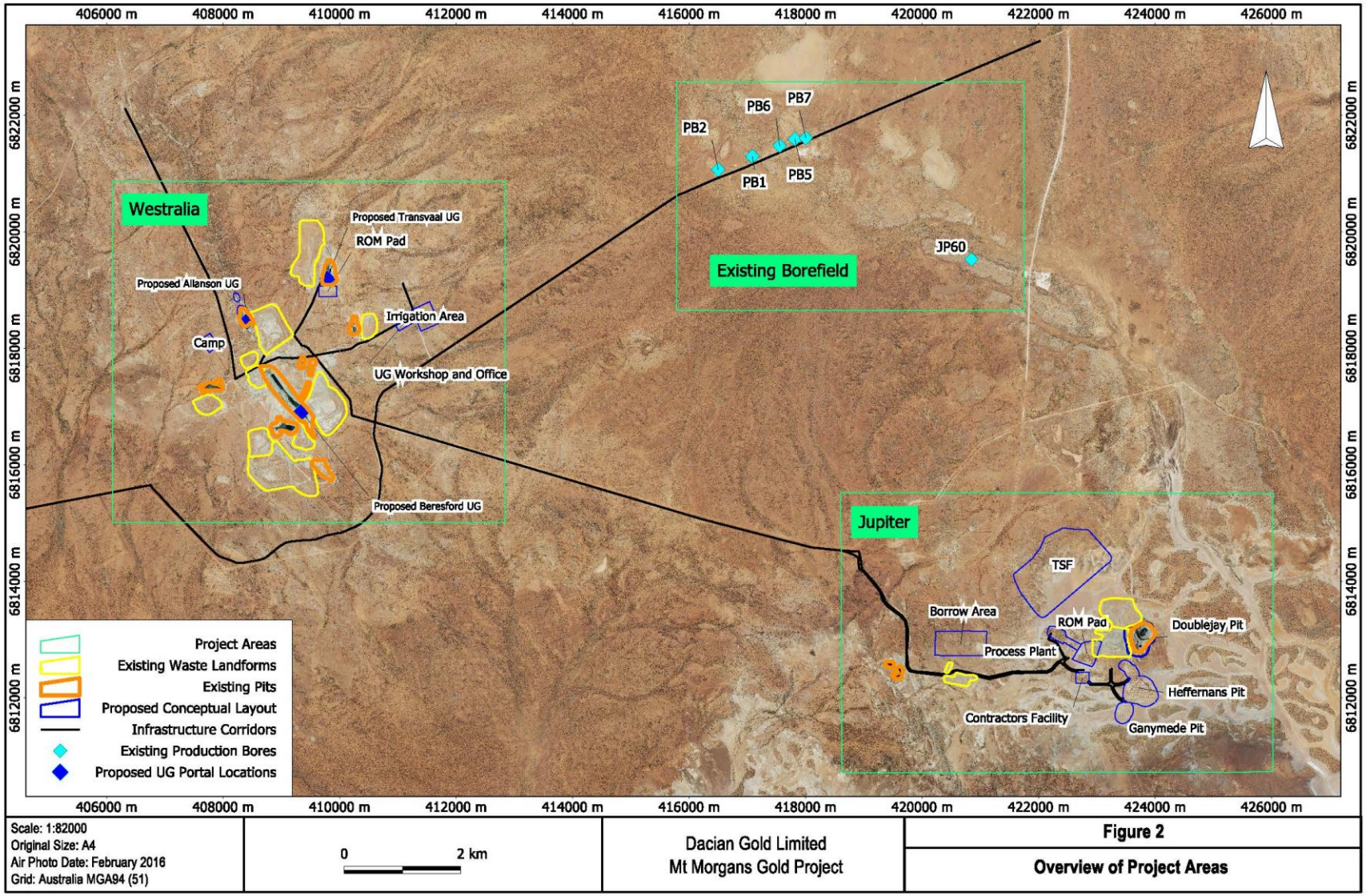

Figure 2. Overview of Project Areas

Chenopod shrublands; BIF ridge; Tall mulga on stony ironstone slopes; and *Acacia* shrubland on stony footslopes and plains beside drainage lines (Outback Ecology 2009b; RPS 2011). There are no known refugia for fauna in the Project vicinity and little is known about the SRE fauna in the vicinity of Mt Morgans.

The climate in the East Murchison subregion of the Yilgarn is arid, experiencing high temperatures in summer and low irregular rainfall over the year (Table 1, Figure 3). The region receives ca. 233 mm of rainfall annually, with the majority falling from January to June. Evaporation far exceeds annual rainfall with approximately 3000 mm per year (Bureau of Meteorology 2016). Average maximum temperatures at the weather station that is closest to the Project (Laverton, Station ID 012045) range from 17.8 °C in winter to 35.8 °C in summer, although temperatures can reach 39.4°C. Average minimum temperatures range from 5.2 °C in winter to 20.5 °C in summer. Fire risk is highest during the summer months.

Table 1. Climatic data for Laverton (Weather Station 012045) since 1900.

Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean maximum temperature (°C)	35.8	34.8	31.9	27.2	22.1	18.5	17.8	20.0	24.5	28.0	32.1	34.9	27.3
Mean minimum temperature (°C)	20.5	20.0	18.0	13.9	9.5	6.6	5.2	6.4	9.5	12.8	16.6	19.3	13.2
Mean rainfall (mm)	25.1	31.0	29.8	22.1	23.2	23.3	16.3	12.9	9.0	9.6	14.6	18.0	233.5
Solar exposure	27.4	24.4	21.0	16.8	13.5	11.6	12.8	16.5	21.0	24.6	27.2	28.3	20.4

Data courtesy of the Australian Bureau of Meteorology website (2016). Red text indicates mean maximums and blue text indicates mean minimums.

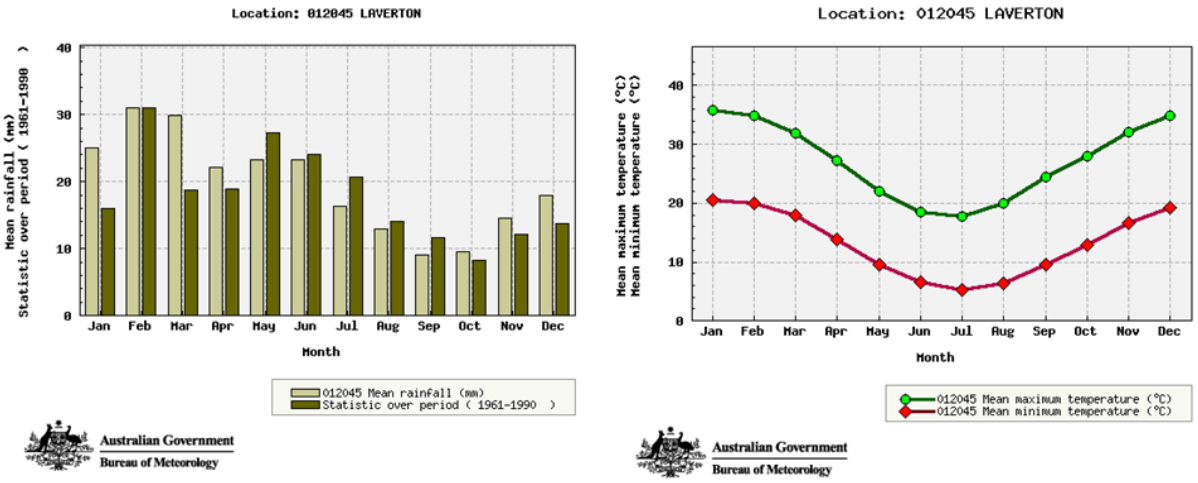

Figure 3. Mean rainfall and mean temperatures for Laverton (Weather Station 012045).

Lands protected under state and federal legislation near Laverton include Goongarrie National Park, Niagara Dam Nature Reserve and Malcom Dam Nature Reserve. However, none of these Reserves are located in the vicinity of the Project. The buffer zone for the Priority 1 PEC '*Mount Morgan calcrete assemblage type on Carey palaeodrainage on Mount Weld Station*' coincides with the Project but this PEC is designated for subterranean fauna and not SREs.

3. FRAMEWORK

3.1. Conservation Framework

Protection of native flora and fauna in Western Australia is provided at both state and federal levels. At the federal level, a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places is provided via the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

At the state level, native flora and fauna are protected under the *Wildlife Conservation Act 1950* (in particular Section 14, pp. 8-9). The highest level of protection is given to Schedule 1 species that are considered rare, likely to become extinct, or otherwise in need of special protection. The current list of threatened species is the Wildlife Conservation (Specifically Protected Fauna) Notice 2015.

The Department of Parks and Wildlife (DPaW) also maintains a list of priority fauna species that are of conservation importance but, for various reasons, do not meet the criteria for listing as threatened. The current list from November 2015 includes 113 terrestrial invertebrate species: seven insects, 26 arachnids, 22 crustaceans, 22 millipedes, one bristle worm and 35 molluscs (DPaW 2015).

Sampling methods for SRE invertebrates are outlined in the Guidance Statement 20 (Environmental Protection Authority 2009), which also provides a theoretical framework for SRE assessments and sampling protocols.

3.2. SRE Framework

It can be difficult to determine whether or not a species belonging to a SRE Group is actually a species with a range <10,000 km^2. The Western Australian Museum (WAM) uses a three-tier classification scheme for SRE species which we have applied to all species listed in this report:

Confirmed SREs are species with a known distribution range <10,000 km^2. The taxonomy is well known and the group is well represented in collections and/or via comprehensive sampling.

Potential SREs are species that belong to a group where there are gaps in our knowledge of the taxon, either because the group is not well represented in collections, taxonomic knowledge is incomplete, or the distribution is imperfectly understood because sampling has been patchy.

Widespread (not SRE) species have a known distribution range >10,000 km^2. The taxonomy is well known and the species is well represented in collections and/or via comprehensive sampling.

The WAM further uses five sub-categories if a species is determined to be a "Potential SRE". These sub-categories are:

1. Data deficient: There are insufficient data available to determine SRE status, either because there is a lack of geographic and taxonomic information, or because the individuals sampled cannot be identified to species level (e.g. wrong sex, juvenile, damaged);
2. Habitat Indicators: The status of a species can be elucidated through its association with a particular habitat and vice versa;
3. Morphological Indicators: The status of a species can be determined through its morphological characteristics;
4. Molecular Evidence: DNA sequence data reveal patterns congruent or incongruent with SRE status for a species; and
5. Research & Expertise: Available research data and/or WAM expertise provide the basis for a decision about the species' status.

It should be recognised, however, that identifying SRE species is part of a filtering process used to determine whether species may be threatened by development. While SRE species have the potential to be threatened because their ranges may fall entirely within an area of disturbance, the actual level of threat to SRE species depends on the relationship between the species range and development footprint. The inference of SRE status is the first step in evaluating potential threats to a species but other factors, such as preferred habitat and amount of habitat disturbance, are also considered and the conservation assessment for particular species is principally on a case-by-case basis.

4. DESKTOP REVIEW

A desktop review process was used to assess whether any listed invertebrate species or a significant SRE community was likely to occur at the Project. The assessment of the SRE community focussed on the eight SRE Groups that are usually targeted during environmental surveys in arid areas: centipedes (Chilopoda), harvestmen (Opiliones), land snails (Pulmonata), millipedes (Diplopoda), pseudoscorpions (Pseudoscorpiones), scorpions (Scorpiones), terrestrial slaters (Isopoda) and spiders (Araneae).

Records of species belonging to the SRE Groups or listed species were compiled for a 100 by 100 km search area surrounding the Project (defined by the coordinates -20.59S; 118.409E and -21.483S; 119.382) from the databases of the Western Australian Museum (WAM). Published research papers, available environmental reports, and online sources such as the Atlas of Living Australia (ALA 2016) and DPaW's NatureMap (DPaW 2007 - 2016) were also reviewed. The search area included many environments that are geologically and climatically similar to the Project area and include the same broader habitat types. The species belonging to SRE Groups that were identified in this search were filtered further by the in-house expertise of the Bennelongia staff as not all species in these groups have ranges < 10,000 km^2 and are of potential conservation concern.

Habitat mapping was also undertaken and the Project was split into distinct habitat types that were evaluated with regards to their suitability for SRE fauna. Using high-resolution orthophotos provided by Dacian, the Project area was split into distinct habitat types which were evaluated further according to five criteria: the likely availability of moisture, soil structure, geological diversity, vegetation type and extent of shading or shelter. The emphasis was on identifying 'relict' habitats (sheltered, moist for millipedes) and those that may contain specialist species (e.g. rocky outcrops for selenopid spiders). The extent of these habitat types beyond the survey area was also evaluated, as well as the extent of habitat connectivity and the presence of habitat isolates that could restrict dispersal in the SRE fauna potentially present. Habitat mapping considered the current knowledge regarding SRE Group ecologies, e.g. trapdoor spiders and millipedes are expected to occur in *Eucalyptus* woodlands but are unlikely to occur on claypans.

4.1. Habitat Characterisation

Preliminary habitat characterisation was undertaken using orthophotos provided by Dacian. Emphasis was given to the identification of macro-habitats likely to support a suitable microclimate for SREs. Based on macro-habitat mapping, Bennelongia distinguishes six major habitat types that differ in their prospectivity for SRE species (Figure 4). These habitats range from low suitability to moderate and high suitability for SRE fauna. Each of these six broad habitat types is described below. The landscape in the south-east of the mapped habitat area hosts a mosaic of habitat types. In this area, fine-scale vegetation mapping provided by Native Vegetation Solutions was applied to the SRE habitat assessment (Figure 5). No additional SRE habitat types were identified in the fine-scale assessment.

Banded Iron Formations and Ridges habitat

This is the least common habitat type locally and some isolated ridgelines occur in the north-west and south-east of the survey area. BIF ridges generally have a high prospect for SRE fauna because they have topographic diversity and offer shelter for relict SRE Groups such as slaters and millipedes. They also tend to support a diverse microhabitat for specialist species such as those that live under rocks such as selenopid spiders and *Synsphyronus* pseudoscorpions (Crews and Harvey 2011; Harvey 1987; Harvey 2010). Diverse communities of millipedes, trapdoor spiders, pseudoscorpions, snails and scorpions have been documented from such habitats in the Yilgarn (Bennelongia 2011; Bennelongia 2014; ecologia Environment 2014) and endemism is generally very high. However, the BIF ridges in the survey area are small, narrow, not very high (20-30 m) and appear to be more exposed with less vegetation cover than those elsewhere in the Yilgarn. It is unlikely that any species would have ranges that fall entirely within this habitat type in the survey area. Nevertheless, it is almost certain that some species in SRE Groups will occur here and there could be limits to dispersal in SRE fauna between the isolated ridges. The BIF ridges in the survey area have a moderate prospect for SRE fauna and may promote some species in both relict and specialist SRE groups.

Calcrete habitat

This was the second least common habitat type in the survey area and occurs in patches in the eastern and north-eastern survey area. Calcretes are not usually considered prospective SRE habitat because they are exposed and have little vegetation cover. The moisture holding capacity may be higher than in Plains habitat as the calcrete basins may flood periodically however they dry quickly afterwards, so are not suitable for refugial SRE fauna that require stable climatic conditions, such as millipedes. Within the SRE Groups, terrestrial slaters may occur in debris or organic matter that has accumulated over time within this habitat and the families Philosciidae and Armadillidae may occur. Some specialist trapdoor spiders may also be found here and wishbone spiders of the family Nemesiidae and spiny trapdoor spiders of the family Idiopidae have been recorded in similar habitat during a previous survey at Mulga Rocks (Bennelongia 2015). Small land snails of the genera *Gastrocopta* and *Pupoides* are expected to occur at low abundance but species in these genera are typically widespread and not of conservation significance. Scorpions will also utilise this habitat type but are unlikely to be restricted to it. The calcretes in the Project area appear to have comparably little prospect for SRE species although the presence of habitat specialists cannot be excluded with the available data.

Minor Creekline habitat

This habitat type occurs throughout the entire survey area but is particularly common in the western sections. Minor creeklines have a higher prospect for SRE fauna because they have elevated moisture-holding capacity, vegetation cover, and are often shaded. Organic matter that provides food and shelter for many SRE invertebrates is also present although this depends on the amount of periodic flooding if it occurs, depth of the creeklines, and integration with the surrounding landscape features (Car and Harvey 2014; Car *et al.* 2013; Edward and Harvey 2010). So-called relict groups that have the potential to occur include slaters of the families Armadillidae and Philosciidae, millipedes, centipedes, harvestmen and terrestrial snails of the families Bothriembryontidae, Camaenidae and Pupillidae. Several families of trapdoor spiders (Actinopodidae, Ctenizidae, Idiopidae and Nemesiidae) have also been recorded from such habitats and they construct their burrows usually on higher ground and banks of the creeklines where no periodic flooding occurs. Habitat-specialists are less likely to occur here although some trapdoor spiders may prefer such habitats and withstand short periods of flooding. More generally, this habitat type is not restricted to the survey area and minor creek lines and tributaries are strongly tied with other habitat types such as the surrounding woodlands, larger creeklines and ranges.

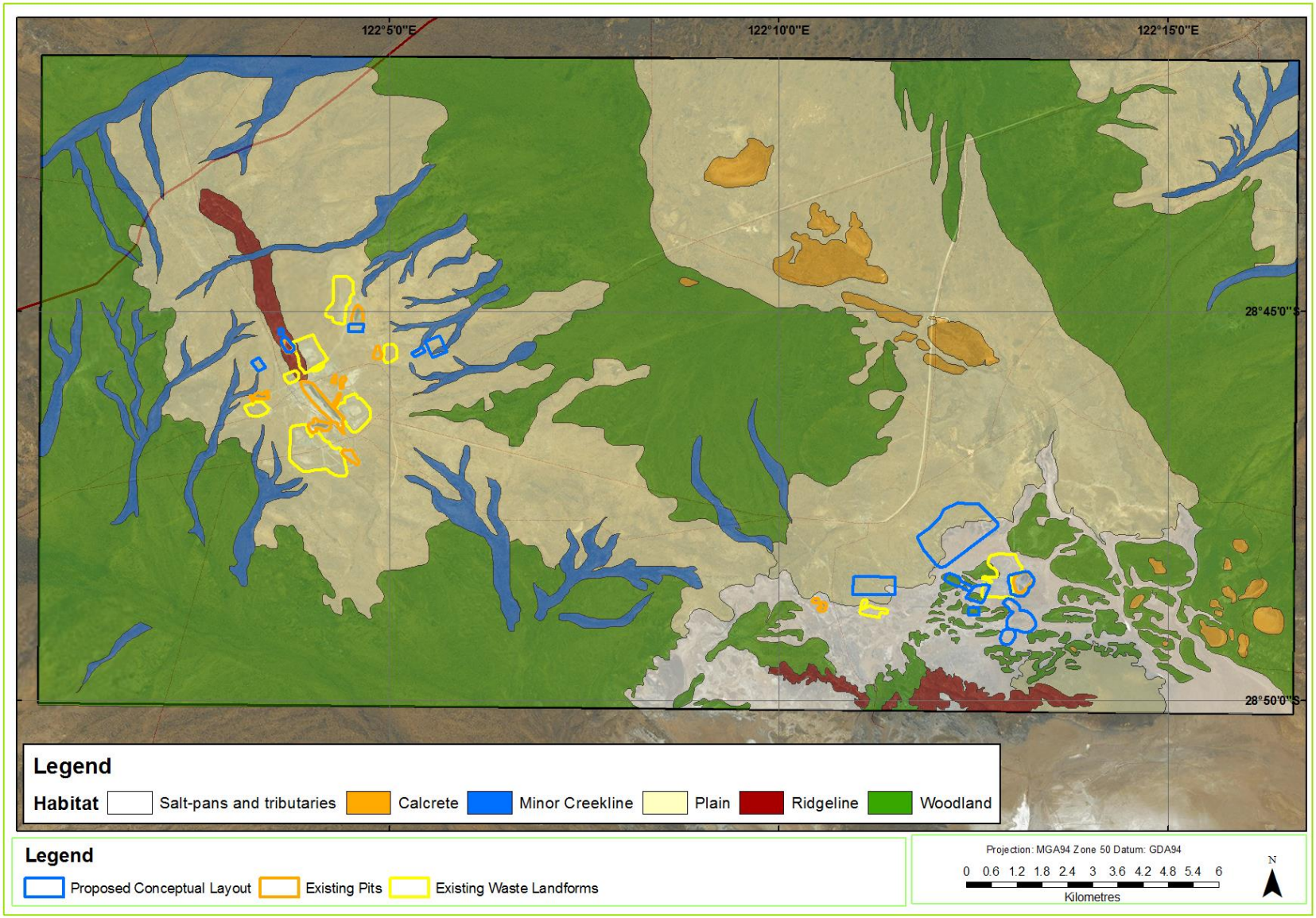

Figure 4. Major SRE habitats at the Mt Morgans Project.

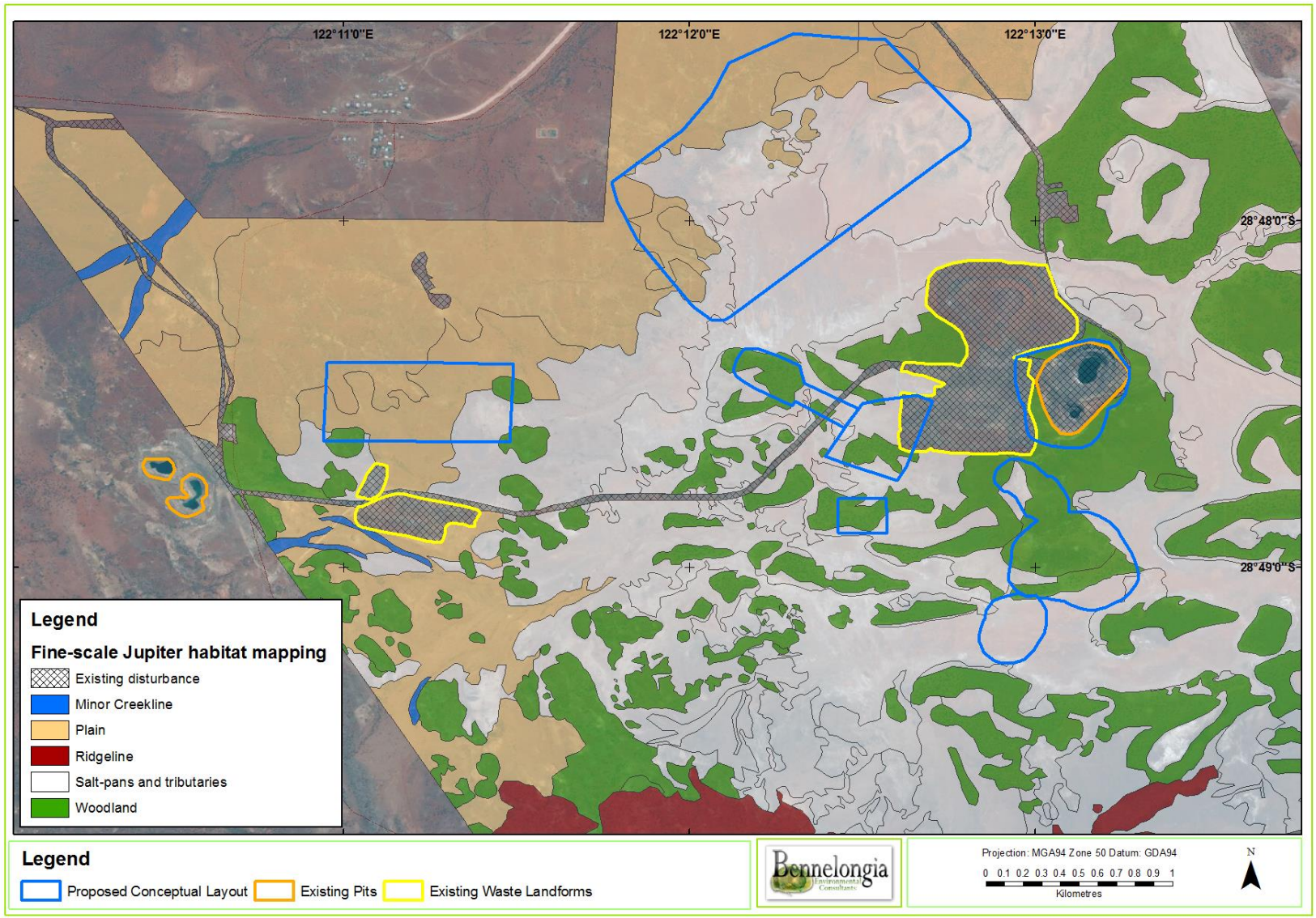

Figure 5. Fine-scale SRE habitats at Jupiter.
Mapping modified from Native Vegetation Solutions 2016.

Plains habitat
This is the second most common habitat type in the survey area and extends well beyond the survey boundaries. It is a relatively exposed habitat type with predominantly shrubby vegetation or open *Eucalyptus* woodlands over yellow or red sands. There are extensive stretches of grasslands that lack complex vegetation associations and contain a lot of exposed substrate. Organic matter is not as frequent as in the Woodlands and microhabitat diversity is lower. However, the Sandy Plains habitat does have some prospectivity for species in SRE groups, with the groups most likely to occur being mygalomorph spiders (in particular the family Nemesiidae), pseudoscorpions of the family Olpiidae and scorpions of the genus *Lychas*. Moisture-dependent SRE groups such as snails and millipedes are less likely to occur. Species in SRE Groups occurring in Sandy Plains are expected to be relatively widespread because of good habitat connectivity.

Salt-pan and tributaries habitat
This is the third-most common habitat type in the survey area and is generally unsuitable for SRE fauna. The salt-pans and tributaries are largely exposed, flat, without vegetation cover and poor in microhabitats that are essential to SRE fauna. Periodic flooding may occur in winter and temperature shifts in summer will be significant. Moisture-dependent SRE fauna such as millipedes and many trapdoor spiders will not tolerate such climatic conditions and habitat specialists, such as some pseudoscorpions and selenopid spiders, are not typically associated with such habitats either. There is some potential for specialist invertebrates to occur, such as wolf spiders of the family Lycosidae, but these do not belong to the SRE Groups and are typically not assessed in EIAs. The salt-pans and tributaries habitat has very little prospect for SRE fauna and extends widely beyond the survey area, without any barriers or isolates that could restrict the dispersal of invertebrates.

Woodland habitat
This is the most common habitat type in the survey area and extends widely beyond the tenement boundaries. It is also the most prospective habitat type for SRE fauna in this area. This habitat type is generally interconnected and occurs broadly, except in the south-eastern portion of the survey area where outliers of woodlands occur in association with salt-pans and tributaries and plains, forming a diverse mosaic of habitat islands (Figure 4, 5). However, these isolates appear too small and are generally too well-interconnected to effectively limit dispersal of any SRE fauna present; hence are not considered to be habitat isolates that could support unique elements of SRE fauna (i.e. endemic species). Woodlands in the Yilgarn generally support highly diverse SRE faunas that comprise several families of trapdoor spiders, millipedes of the genera *Atelomastix* and *Antichiropus* (Car and Harvey 2014; Car, Wojcieszek *et al.* 2013; Edward and Harvey 2010), centipedes of the families Cryptopidae and Geophilidae, diverse snail communities and scorpions of the genera *Lychas* and *Urodacus*. Endemism can be high if the woodlands surround high-elevation features (e.g. BIF ranges) and restrict dispersal in species with specific requirements (i.e. moisture-dependence in millipedes; see Nistelberger *et al.* 2014). Conversely, species in this habitat type can be widespread if the woodlands extend widely, are well-interconnected with uniform vegetation features. Since the woodlands in the survey area fall into this category, species in SRE Groups that prefer this habitat type are expected to be widespread.

In summary, there are six broad habitat types in the survey area. The most prospective habitat types for SRE fauna are woodlands followed by Banded Iron Ridges and Minor Creeklines whereas the remaining three habitat types have little suitability for SRE fauna. None of the more prospective habitat types are restricted at local, sub-regional or regional scales and all habitat types extend beyond the survey area. There are also no habitat outliers, isolates or geological barriers that could restrict dispersal in SRE fauna and lead to small ranges. It appears that all habitat types are generally interconnected and form a diverse mosaic of landscape features across a wide area. The BIF ridges that support diverse SRE communities in other areas of the Yilgarn are a minor element of this mosaic and appear too small and shallow for diverse SRE communities to occur. Woodland habitat is probably the most prospective habitat type but is also the most common one and is spread widely

beyond the survey. SRE fauna in this habitat type is therefore expected to be more widespread; with ranges that extend beyond the survey area.

4.2. SRE Fauna of the Yilgarn

The Yilgarn generally supports very diverse communities of SRE fauna but knowledge is principally derived from surveys undertaken as part of environmental impact assessments as there has not been any systematic-broad scale survey for terrestrial invertebrates in this area, including in the wider Murchison bioregion. The general richness of the Yilgarn may be linked to the specific climatic features such as the rainfall gradient in this Transitional Rainfall Zone (Hopper and Gioia 2004) but also landscape features. High-elevation features such as BIF ranges are embedded into a dense matrix of woodlands and serve as terrestrial islands that promote speciation in this otherwise flat and eroded landscape (Nistelberger *et al.* 2014). Many so-called relict groups persist in local refugia that occur in this landscape matrix but several other groups have undergone extensive radiations and are highly diverse at the species level (Car and Harvey 2014; Car, Wojcieszek *et al.* 2013).

Six diverse families of trapdoor spiders potentially occur in the Project area and include: Actinopodidae, Barychelidae, Ctenizidae, Idiopidae, Nemesiidae, and Theraphosidae. Many of the recorded species are known only from very few specimens and localities, indicating that endemism is high and distribution ranges are often small (Castalanelli *et al.* 2014; Harms and Framenau 2013; Main 1983; Main 1986; Main 2008; Raven 1994). Some of the idiopid and barychelid genera (e.g. *Aganippe* and *Synothele*) are highly diverse at a species level and will include dozens of species; most of which are currently undescribed. Wall-crab spiders of the family Selenopidae are also diverse and endemic species have been collected from under rocks in isolated BIF formations and rocky ridges.

The multipede (millipede and centipede) fauna is also very diverse at the species level. Two genera of millipedes are of conservation significance: all described species of the megadiverse genus *Antichiropus* in the Yilgarn are SRE species and have ranges < 10,000 km^2 (Car and Harvey 2014; Car, Wojcieszek *et al.* 2013). The same pattern is being observed in *Atelomastix* that also includes a high proportion of listed species (Edward and Harvey 2010). The centipede faunas are virtually unknown taxonomically but the families Geophilidae and Cryptopidae are collected frequently during fauna surveys in the Yilgarn and contain at least some potential SREs.

Terrestrial slaters are common in woodlands, BIF formations and creekline habitats. Genera such as *Buddelundia* are megadiverse at a species level, although there is no taxonomic framework for terrestrial slaters in Western Australia and the assessment of putative ranges is extremely difficult with current knowledge fragmentary (Judd and Horwitz 2003). Slaters are collected in almost every invertebrate fauna survey in the Yilgarn and are one of the prime target groups in SRE assessments.

Terrestrial snails are also collected frequently during fauna surveys in this region. Of these, the genera *Pupoides* and *Gastocopta* comprise widespread species but the families Camaenidae and Bothriembryontidae are extremely diverse at the species level and comprise mostly undescribed SREs (Breure and Whisson 2012; Whisson and Kirkendale 2014). The snail genus *Bothriembryon* in particular is currently the focus of systematic study and it appears that there is major diversity and endemism in this fauna. The Succineidae also occur in the Yilgarn but not much is known about species ranges and the taxonomy is generally unresolved. Freshwater snails are also diverse but often have wider-ranges and are not always included in SRE fauna assessments.

Harvestmen, pseudoscorpions and scorpions occur more widely throughout this region. Within the scorpion fauna, the genus *Urodacus* includes a moderately high proportion of potential SRE species because there are a number of lithophiles (species that live under rocks) that may be restricted to specific BIF ranges and have patchy distributions within these habitats. In contrast, the genus *Lychas* predominantly comprises widespread species of sandy plains and open woodlands although there is no taxonomic revision and species identification is virtually impossible. The pseudoscorpion genus

Synsphyronus also includes many range restricted species that live under rocks on BIF, with additional species collected from tree bark currently considered more widespread (Harvey 1987; Harvey 2010). Genera such as *Austrochthonius*, *Austrohorus* and *Amblyolpium* are taxonomically unrevised but thought to include at least some SRE species. Not much is known about harvestmen in the Yilgarn but based on biological characteristics (moisture-dependence, restriction to leaf litter habitats) this fauna will include SREs.

In summary, the Yilgarn has a highly diverse SRE fauna at all taxonomic levels that most likely exceeds those of the Pilbara and south-coast. Most SRE species have been collected from BIF ranges (e.g. Bennelongia 2011; ecologia 2014) and the surrounding woodlands whereas very few SRE species have been collected from other habitat types (e.g. calcretes in palaeochannels, open plains).

4.3. Previous Fauna Surveys

There has been no systematic survey for SRE invertebrates in the Murchison bioregion and only a few fauna surveys have been carried out in the vicinity of the Project as part of environmental impact assessments. Previous assessments collated data on SRE fauna and habitats in the Project area but did not conduct any SRE surveys. They are:

1. Outback Ecology 2009: *Mount Morgans The Craic Project: Level 1 Flora and Fauna Assessment*; and
2. RPS 2011: *Mount Morgans Mine – Morgans North. Level 1 Flora and Fauna Assessment*.
3. Blueprint 2015 – *Mt Morgans Gold Project. Summary of Information Relating to Subterranean Fauna and Short Range Endemics*.

All assessments concluded that no significant SRE fauna community was likely to occur at the Project. The Outback Ecology 2009 report did not identify any suitable habitats (or SRE species) but the 2011 RPS report identified BIF ranges and as potentially important habitat for SRE fauna. The Blueprint 2015 report summarised the data from the two previous reports.

Additional fauna surveys have been carried out by Rapallo Consulting in 2007 east of Leonora and Mt Milkenny, Biota Environmental Sciences in 2010 at Lake Carey and Terrestrial Ecosystems in 2011 at Granny Deeps. The invertebrate data contained in these reports were available through the WAM databases as these specimens have been lodged. Some additional reports that may be of relevance are not in the public domain and could not be checked. These include Jupiter Mines Central Yilgarn Iron Project Level 1 Flora and Fauna Assessment (Outback Ecology 2013). In general, the SRE assessments have indicated that the SRE communities in similar habitats as those present at Mt Morgans are depauperate.

4.4. SRE Fauna near the Project

No SRE field surveys have been carried out at the Mt Morgans Project. Similarly, comparably little is known about the SRE fauna in the search area around the Project because relatively few fauna surveys have been conducted here to date (the available environmental reports are desktop assessments without SRE field survey); taxonomic papers predominantly describe species from the southern Yilgarn (e.g. Car, Wojcieszek *et al.* 2013), and resource developments have been focused largely on larger BIF formations that do not occur in the search area. The primary data source is therefore the database of the Western Australian Museum (WAM).

Based on the data available, the SRE fauna at the Project is probably depauperate by Yilgarn standards (Table 2). The most dominant SRE group is the mygalomorph spiders that are represented by four families and eleven genera. Most of the species are widespread although several juvenile and female specimens have been collected over the years that may belong to SRE species, although not confirmed. The described species, such as *Aname mellosa*, *Aname tepperi* and *Aurecocrypta lugubris* are all widespread and have ranges >10,000 km^2 (e.g. Harvey *et al.* 2012). A goblin spider of the genus *Opopaea* has also been recorded from a juvenile specimen. Goblin spiders can be SRE species (Baehr

and Harvey 2013) but the species identity of the single specimen from the search area is uncertain. Scorpions are represented by three genera in two families. All but one species occur widely in the xeric regions of Western Australia and are frequently collected during fauna surveys. One scorpion, *Urodacus* 'yeelirrie; may be more restricted but too little is known about this species to infer ranges. Centipedes appear moderately diverse with five species and genera in the single family Scolopendridae. Cryptopid centipedes are also known from subterranean habitats in the survey area (WAM database) and are expected to occur in near-surface habitats at the Project. Five of these species are widespread across Western Australia and the single cryptopid specimen is too poorly known for an assessment. No terrestrial snails and slaters have been collected in the search area to date. No millipedes have been collected from this area either, which is evident from maps contained in the published literature (Car, Wojcieszek *et al.* 2013).

Even under consideration that this area is poorly surveyed for SRE fauna and that relatively few environmental reports are available for review, this area is considered to have little prospect for species with ranges <10,000 km^2. All species for which detailed distribution data are available (i.e. the described species) have wide ranges that extent far beyond the survey area. This pattern can be observed in three faunas independently: mygalomorph spiders, scorpions and centipedes. All potential SRE species in Table 2 have an uncertain taxonomy (they are juveniles, the wrong sex for identification or generally undescribed) and their ranges are unknown. These species are potential SREs with deficient data according to the framework of the Western Australian Museum.

Table 2. SRE Groups recorded previously from the search area.
Records collated from the WAM database, published information, online databases and publically available environmental reports. Species 'sp. indet' are records based on juvenile or female specimens that cannot be identified based on morphology. 1= WAM database and WAM staff interpretation of SRE status.

Taxonomic Groups	Species	SRE Status	No. of Records	Source/Reference
Arachnida				
Araneae (Mygalomorphae)				
Actinopodidae	*Missulena occatoria*	No	2	1, Harms and Framenau 2013
	Missulena sp. indet. (juvenile)	Potential	2	1, Harms and Framenau 2013
Barychelidae	*Aurecocrypta lugubris*	No	1	1, Raven 1994
	Idiommata sp. indet. (juvenile)	Potential	2	1, Raven 1994
	Mandjelia 'wanjarri'	Potential	3	1, Raven 1994
Idiopidae	*Aganippe* 'MYG017'	Potential	1	1, Castalanelli *et al.* 2014
	Aganippe sp. indet.	Potential	5	1,
	Anidiops sp. *indet.*	Potential	1	1
	Euoplos sp. indet.	Potential	9	1
Nemesiidae	*Aname* 'brown wish-bone'	Potential	1	1, Castalanelli *et al.* 2014
	Aname mellosa	No	13	1, Harvey *et al.* 2012
	Aname sp. indet. (juvenile)	Potential	6	1, Castalanelli *et al.* 2014
	Aname tepperi	No	2	1, Harvey *et al.* 2012
	Kwonkan 'MYG175'	No	2	1, Castalanelli *et al.* 2014
	?*Teyl* sp. indet. (juvenile)	Potential	5	1
Theraphosidae	*Selenocosmia* sp. indet.	Potential	1	1
	Selenocosmia 'wacarina'	Potential	1	1
Araneae (Araneomorphae)				
Oonopiidae	*Opopaea* sp.	Potential	1	Baehr and Harvey, 2013
Scorpiones				
Buthidae	*Isometroides* sp.	No	1	1
	Lychas jonesae	No	4	1, ALA 2015
	Lychas splendens	No	1	1, ALA 2015
,	*Lychas* sp. indet.	No	2	1, ALA 2015
Urodacidae	*Urodacus hoplurus*	No	33	1, ALA 2015
	Urodacus yaschenkoi	No	5	1, ALA 2015

Taxonomic Groups	Species	SRE Status	No. of Records	Source/Reference
	Urodacus cf. *armatus*	No	3	1, ALA 2015
	Urodacus 'yeelirrie'	Potential	2	1
Chilopoda				
Scolopendromorpha				
Scolopendridae	*Arthrorhabdus paucispinus*	No	1	1, ALA 2015
	Cormocephalus michaelseni	No	1	1, ALA 2015
	Cormocephalus turneri	No	1	1, ALA 2015
	Scolopendra laeta	No	2	1, ALA 2015
	Scolopendra morsitans	No	9	1, ALA 2015

4.5. Listed Species at the Project

There are no PECs or TECs in the vicinity of the survey area that have been listed on a basis of terrestrial SRE taxa. Priority species listed in DPAW's Wildlife Conservation Notice includes the Arid Bronze Azure Butterfly *Ogyris subterrestris petrina*, the Inland Hairstreak *Jalmenus aridus*, the trapdoor spider *Kwonkan moriartii*, and the shrimps *Branchinella apophysata*, *B. basispina*, and *B. denticulata*.

The critically endangered butterfly *Ogyris subterrestris petrina* is known from two sites near Kalgoorlie (ALA 2016) and occurs in mallee-dominated woodland. This species depends on the sugar ant (*Camponotus terebrans*) with the butterfly depositing eggs at the entrances of sugar ant nests that abut the base of living trees and shrubs of various species. There are no records of this species (either historical or recent) in the search area and this species is unlikely to occur here. In the event that it does occur, its primary habitat will be woodlands habitats (where the host ant constructs the nests) and this habitat type is the most common in the survey area, extending widely beyond the tenement boundaries, and will receive minimal impact from the proposed Project. There is no threat to *Ogyris subterrestris petrina* from Project development.

The near-threatened butterfly *Jalmenus aridus* is known from a handful of records near Kalgoorlie and Ngaanyatjarraku in the Northern Yilgarn, indicating that it may be rare but more widespread in the Yilgarn. The species is not commonly collected and poorly represented in Australian research collections. The larvae of this butterfly feed on the leaves and flowers of *Senna* sp. and *Acacia tetragonophylla* (Graham and Moulds 1988). Both host plants occur more widely in the Yilgarn and are generalist species that do not occur on specific geologies or soils, so potentially this butterfly is also more widespread but poorly sampled. Both *Senna* sp. and *Acacia tetragonophylla* plants occur in the survey area but almost all records of this butterfly are near Kalgoorlie and there is no indication that this species should occur in the survey area. Hence it is not of relevance to the current assessment.

The near-threatened wishbone spider *Kwonkan moriartii* is known only from Kathleen Valley Station north of Leonora (Main 1983). Only the male holotype is known (ALA 2016) and the distribution range of this species is unclear at present, with no data available on the biology and ecology of the species. There are no records of this species in the search area surrounding the Project. Many *Kwonkan* species have very short ranges and are confined to specific soil types or geological features, with field data suggesting that some species prefer open plain habitats whilst others are confined to BIF habitats (Bennelongia, unpublished data). Given the short-ranges of most *Kwonkan* species and the absence of records from elsewhere in the Yilgarn (despite many SRE surveys in the southern Yilgarn over the last decade) it is reasonable to assume that this species is restricted to the area surrounding Kathleen Valley Gold Mine.

Three fairy shrimp species of the genus *Branchiella* are listed from the Yilgarn. Only one of these has the potential to occur in the Project area: *Branchinella simplex*. This is a species of fresh and hyposaline waters on clay pans and it "has been found in a wide band (linear range of 550 km) across the middle of the state" with records from Larkes Dam, Mongers Samphire Pan, and Lakes Arrow,

Cronin and Kopai (Timms 2002). More recent records include saline waters of Lake Carey (in the vicinity of the Project area) and it is now believed that this species has a wide tolerance for salinity levels (Timms 2008) and a fairly wide distribution in ephemeral water bodies around Kalgoorlie. It is a passive disperser and the eggs may be passed through the digestive tract of wetland birds, with dispersal occurring between the ephemeral clay pans when they are flooded. It is possible that this species occurs in the salt-pan and tributaries habitat in the south-eastern and eastern study area but no records have been documented. If it does occur, its local distribution would reflect the extent of these clay pans that extend more widely beyond the search area. Whilst having the potential to occur within the Project area, minimal impact is expected and the project is not considered likely to impact the viability of the population of *B. simplex* if present (Figure 5).

4.6. Summary of Desktop data

The review of broader habitat types revealed that there are six habitat types (Figure 4, 5) of which only one (woodlands habitat) has a high suitability for SRE fauna. BIF ridges and rocky hills that usually support diverse SRE communities in the Yilgarn are too poorly developed at the Project to host such communities. The woodlands are likely to support SRE fauna but this is the most common habitat type in the survey area, is generally interconnected, and extends widely beyond the tenement boundaries. Hence, species found in this habitat type will be more widespread with ranges that mirror the wide distribution of these woodlands.

The SRE community in the vicinity of the Project is poorly known because very few SRE fauna surveys have been undertaken but, nevertheless, appears quite depauperate by Yilgarn standards. Three SRE Groups seem to be moderately diverse: mygalomorph spiders, scorpions and centipedes. All named species in these groups are widespread and have ranges that extend far beyond the survey area. The potential SRE species identified in these groups have an unresolved taxonomy and are SREs with deficient data according to the WAM framework, meaning that their ranges cannot be assessed and that they may be more widespread also. Groups that typically have a high proportion of SRE species, e.g. slaters and millipedes, have not been documented in the search area. In general, it is expected that the Project will host poorly developed SRE fauna that comprises predominantly widespread species.

Five listed species are known from the Yilgarn but four of these are unlikely to occur at Mt Morgans. The fairy shrimp *Branchinella simplex* may occur in the salt-pan and tributaries habitat at the Project but has not been collected and is fairly widespread in the Murchison. This species is found in ephemeral habitats and has well-developed dispersal capacities. The impact to this habitat type will be minimal.

5. CONCLUSIONS

This desktop review collated existing information on SREs and listed invertebrate species that may occur within the Mt Morgans Project and its vicinity, and characterised habitats according to their suitability for SRE fauna.

The review identified three habitat types that have a moderate or high prospect for SRE fauna. Of these, the BIF Formations and Ridgeline habitat has potential for both relict and specialist SRE species but is also the least common habitat type in the survey area and is too small to support diverse SRE communities. Minor Creekline habitats and Woodlands habitats are much more common in the study area but not restricted at a local, sub-regional and regional scale. Species that occur in these habitat types will be more widespread. The SRE fauna at the Project, as currently documented, is poorly developed and almost exclusively comprises widespread species in three taxonomic groups (mygalomorph spiders, scorpions and centipedes) although there are some potential SRE species with deficient data. Only one listed species (*Branchinella simplex*) has the potential to be present locally but occurs in a habitat type that will have minimal impact from the development.

While the final locations of all disturbance areas are still pending, the assessment of threat to SRE fauna is considered to be minimal given the indicated small size of the proposed impact areas. Bennelongia is not aware of any SRE species with ranges so small that they could fall entirely within the impact areas, especially considering that the disturbance areas will be located in habitat types that are either unsuitable for SRE fauna (plains and salt-pans and tributaries habitat in the south-east; Figure 4, 5), or occur in a BIF ridge that extends further to the north and has already been impacted by past mining.

Overall, there is minimal impact on SRE or listed species from the proposed mining operation. A field survey that could help to characterise the local SRE community and validate the findings of this desktop review appears unnecessary given that the known SRE fauna in this area is depauperate and comprises widespread species, but also the small scale of the Project impact. There is no foreseeable threat to either SRE fauna or listed species from the Project and it is suggested that SRE invertebrates are not a relevant environmental assessment factor at the Mt Morgans Project.

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